Visuel and semiquantitative analysis of Tc-99m dmsa scintigraphy in children with pyelonephritis

Piyelonefrit hastalarında Tc-99m dmsa sintigrafisinin görsel ve semikantitatif analizi

Analysis of Tc-99m dmsa scintigraphy

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Öz

Amaç: Bu çalışmanın amacı pyelonefrit esnasında ve takip eden dönemde böbreklerde skar tesbiti için yapılan 99mTc-DMSA statik böbrek sintigrafisinde görsel ve kantitatif methodların karşılaştırılmasıdır. Gereç ve Yöntem: Çalışmaya 21 çocuk hastanın (6,6±3,2 y old (mean±SD)) pyelonefrit sırasında (DMSA1) ve 12,4±6,8 (mean±SD) ay sonra (DMSA2) yapılan 99mTc-DMSA statik böbrek sintigrafileri dahil edildi. DMSA1 ve DMSA2 için öncelikle görsel değerlendirme, ikinci olarak da semikantitatif bir değerlendirme uygulandı. Böbreklerin görsel skorlaması; 9 puan üzerinden yapıldı. ≥7 skorlarda böbrek normal olarak değerlendirildi. <7 olan böbrekler anormal olarak değerlendirilip, DMSA1 ve DMSA2' de böbrekler normal(N) and defektif(DF) olarak iki gruba ayrıldı. Semikantitatif analizde DMSA sintigrafilerinde böbrekler otomatik eşik (%20-80) kullanılarak yüzey alanı (S) ve sayım (C) değerleri hesaplandı. Daha sonra %30-%80 eşikteki değerler, %20 eşik değerine oranlanarak nisbi yüzey alanı (nS%) ve nisbi sayım oranı (nC%) olarak iki parametre hesaplandı. Bulgular: Semikantitatif analizde nC70 ve nS70 değerleri DMSA1' de uygulandığında en iyi parametreler olarak bulundu (böbrekte N ve DF grup ayrımı için) (table1). nC70 değeri için N ve DF grup ayrımında eşik değer 0,34 olarak alındığında; sensivite %55 , spesifite %100 olarak bulundu. nC70 değeri DMSA2 için uygulanıp eşik değeri 0,34 olarak alındığında ve görsel skorlama ile karşılalştırıldığında N ve DF grupta 16/42 (%38) böbrekte grup değişikliği olmuştur. Tartışma: Bu çalışma Tc-99m DMSA renal sintigrafinin daha objektif değerlendirilmesi için kantitatif analiz parametrelerinin geliştirilmesinin gerekliliğini düşündürmüştür.

Anahtar Kelimeler

Tc-99m DMSA; Pyelonefrit; Semikantitatif Analiz

Abstract

Aim: The aim of the study is to evaluate a quantitative method in comparison with a visual method based on 99mTc-DMSA renal planar scintigraphy performed during pyelonephritis (PN). Material and Method: A total of 21 children (6,6±3,2 y old (mean±SD)) were examined by 99mTc-DMSA scintigraphy during (DMSA1) and 12,4±6,8 month (mean±SD) after (DMSA2) PN. Two levels of interpretation were performed independently: first, a visual analysis to classify the kidneys by considering the evolution between DMSA1 and DMSA2, and second, a semiquantitative analysis of DMSA1 and DMSA2. A visual method of kidney evaluation, 9-point visual analysis of each kidney was performed. A kidney was considered normal when the score was ≥7. Renal scarring was defined as a score of <7 on DMSA1 and DMSA2, and 2 groups were obtained normal(N) and defective(DF). Semiquantitative analysis of kidney evolution; was performed to an automatic threshold (%20-80) for the kidney and then calculating ratios of the count density and number of pixels (nC%= C in a given isocount/ C in a 20% isocount, nS%=S in a given isocount/S in a 20% isocount). Results: For the semiquantitative analysis, the nC70 ve nS70 ratio was considered the best index to classify the kidneys by considering the evolution between DMSA1 (to determine which kidneys N or DF group) (table1). When this nC70 ratio was used a cutoff value of 0,34, it was able to differentiate between N and DF groups with a sensitivity of %55, a specificity of %100. According to the semiquantitative analysis of DMSA-2, when the cutoff value of C70% (0.36) was taken into consideration, 12 of 15 kidneys were in the N group, and 14 of 27 were in the DF group. As a result, a group change occurred in 16/42 (%38) kidneys. Discussion: We concluded that the assessment of DMSA scintigraphy might show significant interobserver variation and that there was a need for quantitative parameters to make more objective evaluations.

Keywords

Tc-99m DMSA; Pyelonephritis; Semiquantitative Analysis

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Introduction

Acute pyelonephritis (APN) is a common infectious disease during childhood [1]. Severe sequelae such as hypertension, renal failure, and end-stage kidney disease could develop if the infection leads to chronic pyelonephritis(PN) [2]. Tc-99m DMSA scintigraphy is a simple and practical technic for evaluation and follow-up of children with APN [3]. Experimental studies have validated DMSA scintigraphy as an accurate technique for the detection of both acute infection and chronic lesions [4,5]. In past years, many studies reported that 99mTc-DMSA scan has high sensitivity and specificity as a diagnostic test for PN [6-8]. Studies have been published in the past years about reproducibility on 99mTc-DMSA [8-12]. In this studies , reproducibility on 99mTc-DMSA related to the different results was found.

The aim of the present study was to assess the performance of a previously described quantitative method as compared to visual evaluation of Tc-99m DMSA renal scintigraphy in patients with PN. Our second aim was to determine the most suitable parameter for the semiquantitative analysis.

Material and Method

Patients

A total of 21 children (6,6±3,2 years old (mean ±SD)) were examined by Tc-99m DMSA scintigraphy in the acute phase of PN (DMSA-1) and 12,4±6,8 months later (DMSA-2). Patients information and images were evaluated retrospectively. APN was diagnosed by pediatricians according to clinical and laboratory findings, based on fever, positive urine culture, lumbar fossa pain, etc.

Acquisition

Tc-99m DMSA scintigraphy was performed following the recommendation of the European Association of Nuclear Medicine Pediatric Task Group. DMSA-1 ve DMSA-2 were performed 4hours after iv. injection of Tc-99m DMSA (Mon.DMSA, Monrol, Turkey) by use of a dual head gamma-camera (TOSHIBA E-CAM), with LEHR parallel collimator in 128*128 matrix and acquiring a total of 1000 kcounts from anterior, posterior, and oblique positions.

Tc-99m DMSA Scintigraphy Analysis

In the visual method, each kidney was evaluated by 9-points of a visual scoring system by two observers. The kidney was divided into three sections (superior, medium, and inferior pole) and each section was scored from 0 (no uptake) to 3 (normal uptake). A kidney was considered normal when the total score was ≥7. Renal scarring was defined when the score was <7 on DMSA-1 and on DMSA-2. Thus, kidneys were classified into two groups as, normal (N) and defective (DF) (Figure 1.). Interobserver reproducibility between the two observers was determined by kappa analysis. The first observer's visual score was used to compare quantitative analysis.

Semiquantitative analysis; for each kidney, the values of surface area (S) and count (C) in each value were calculated using the automatic threshold values of 20%, 30%, 40%, 50%, 60%, 70%, 80% (figure2). Then, the two parameters, calculated as the relative surface area (nS%) and the relative count ratio (nC%), were calculated using the following formula.

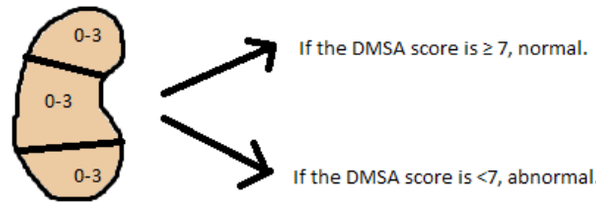


Figure 1. Schematic representation of the visual scoring system

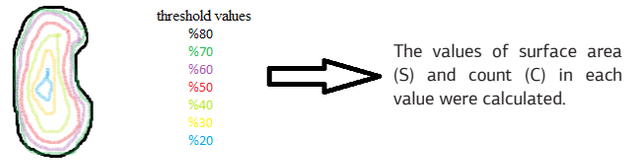


Figure 2. Schematic representation of the semiquantitative analysis

nS% = surface area at the relevant area (number of pixels)/ surface area at the relevant area at 20%(number of pixels)

nC% = average count in the relevant area / average count in the relevant area at 20%

Statistical Analysis

Variables were expressed as mean ±SD. Comparison of groups was based on paired t-test, and the relationship between two variables were expressed with Pearson correlation coefficient. ROC analysis was used in the calculation of sensitivity, specificity, positive and negative predictive values of nC% and nS% in the semiquantitative analysis. P<0.05 was accepted as significant.

Results

In the assessment of interobserver reproducibility, kappa value was calculated as 0.516 in visual scoring. According to this analysis, interobserver agreement reproducibility in reporting on the 99mTc-DMSA scan was moderate.

According to visual analysis of DMSA-1, 13 kidneys were stratified in the N group (mean score; 7.27±0.46) and 29 kidneys in the DF group (score; 4.63±1.18) (p<0.001).

All of the semiquantitative parameters (nC% and nS% values) and their comparative analysis results were given in Table 1.

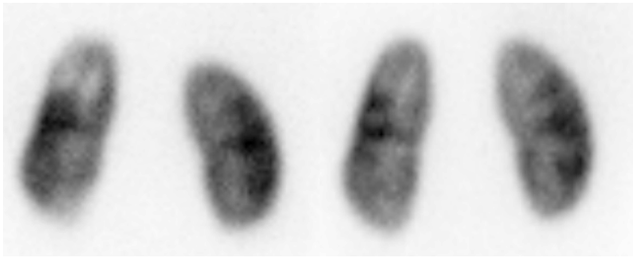
In ROC analysis when C70% was used for the discrimination of N and DF patients, a cutoff value of 0.34 was found to be able to differentiate N patients from DF group. In this case, the sensitivity of C70% was %55, and specificity was %100 (AUC=0.79, SE=0.082). A cutoff value of 0.26 was found for S70%. Sensitivity was %62 and specificity was %92 (AUC=0.81, SE=0.08) for this value.

In the visual analysis of DMSA-2, 15 kidneys classified as in the N group (score; 7,27±0,46) and 27 kidneys in the DF group (score; 4,63±1,18) (p<0.001). According to the semiquantitative

Table 1. Semiquantitative parametres (nC% and nS% values and comparative analysis for DMSA 1.

Semiquantitative parameters	Normal Group	Defective Group	P
nS30%	0.87±0.03	0.85±0.03	0.056
nS40%	0.77±0.05	0.72±0.06	0.026
nS50%	0.66±0.07	0.59±0.09	0.017
nS60%	0.51±0.08	0.42±0.09	0.006
nS70%	0.32±0.06	0.24±0.08	0.001
nS80%	0.32±0.06	0.24±0.08	0.012
nC30%	0.94±0.02	0.93±0.02	0.050
nC40%	0.88±0.03	0.85±0.04	0.015
nC50%	0,80±0.05	0.74±0.08	0.009
nC60%	0.65±0.08	0.56±0.09	0.004
nC70%	0.45±0.07	0.35±0.09	0.001
nC80%	0.23±0.05	0.18±0.07	0.024

analysis of DMSA-2, when the cutoff value of C70% (0.36) was taken into consideration, 12 of 15 kidneys were in the N group, and 14 of 27 were in the DF group. As a result, a group change occurred in 16/42 (%38) kidneys (Figure 3).



DMSA-1 DMSA-2

Figure 3. Comparison of Tc-99m DMSA scintigraphy results by visual and semiquantitative analysis in the PN evolution. Posterior views in a 7-y-old girl. In the visual analysis of DMSA-1, right kidney was considered to be in the N group (7 points), while left was in the DF group (5 points). In the visual analysis of DMSA-2 (six months later), right and left kidneys were assessed in N group (7 points). According to the semiquantitative analysis of DMSA-2, right kidney was classified in the N group (nC70= 0,39) and left kidney in the DF group (nC70=0,20).

Discussion

APN is a potential organ and/or life-threatening infection that often leads to renal scarring. DMSA (Dimercaptosuccinic acid) localizes by binding to the sulfhydryl groups in the proximal renal tubules. So, Technetium-99m (Tc-99m) DMSA is an excellent cortical imaging agent for diagnosis of APN. But interobserver variability has been shown to influence visual DMSA scintigraphy evaluations [9-12]. We performed a semiquantitative analysis to reduce inter- and intraobserver variability in visual analysis of DMSA renal scintigraphy. First, we have investigated interobserver variability in the visual assessment of Tc-99m DMSA renal scintigraphy in APN. Kappa analysis showed that there was a moderate agreement (0.516) between visual analysis of two observers. These findings indicate that visual analysis of DMSA renal scintigraphy has included the subjective factors. Various studies were carried out to investigate the interobserver reproducibility of visual analysis of DMSA renal scintigraphy. One of these studies is the study of Tondeur et al. in which, 61 observers from different nuclear medicine units have evaluated Tc-99m DMSA renal scintigraphies by classifying as normal, abnormal, suspicious and uninterpretable in pediatric patients. In this study, 13% of disagreement was observed between the discrimination of normality and abnormality [9]. In another study, Çağlar et al. have investigated interobserver reproducibility. In this study, oblique views were found useful in approximately %13 of kidneys and affected inter- and intraobserver variability [12].

In the second step, a semiquantitative analysis was carried out, which consisted of determining a threshold for kidney (DMSA-1) and then calculating nC% and nS% ratios. In this analysis, nC70% and nS70% ratios were considered the most appropriate parameters. With these ratios, a cutoff value of 0.34 for nC70, and 0.26 for nS70 were found to be effective in the discrimination of N and DF kidneys. When these cut-off values were applied to DMSA-2, a group change occurred in 16/42 kidneys (38%) for the first observer, and in 9/42 kidneys (21%) for the second observer.

In the study of Hitzel et al., a cut-off value of 0,45 for the C%70 ratio was calculated, which might help to predict renal scarring in DMSA scintigraphy during APN [1].

Some of the researchers tried to use lesion volume in the prediction of late complications of APN. In the study of Chiou et al., they have evaluated whether lesion volumes in APN were derived from Tc-99m DMSA renal SPECT images is predictive of the development of subsequent renal fibrosis. According to their report, there was a correlation between volume of photopenic lesions with subsequent scars when a lesion volume was ≥4,6 cm3 [2].

In a study by Sampedro et al. using a fully automated lesion detection and segmentation system, they found that the system was able to successfully classify DMSA-positive from negative scans (AUC=0.92, sensitivity=81%, and specificity=94%). And they said that a computational framework for the quantification of structural renal damage from DMSA scans showed a promising potential to complement visual diagnosis and non-imaging indicators [13].

Conclusion

We concluded that the assessment of DMSA scintigraphy might show significant interobserver variation and that there was a need for quantitative parameters to make more objective evaluations.

Competing interests

The authors declare that they have no competing interests.

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References

1. Hitzel A, Liard A, Dacher JN, Gardin I, Ménard JF, Manrique A, et al. Quantitative Analysis of 99mTc-DMSA During Acute Pyelonephritis for Prediction of Long-term Renal Scarring. J Nucl Med. 2004; 458(2): 285-9.
2. Chiou YY, Wang ST, Tang MJ, Lee BF, Chiu NT. Renal fibrosis: prediction from acute pyelonephritis focus volume measured at 99mTc dimercaptosuccinic acid SPECT. Radiology. 2001; 221(2): 366-70.
3. Treves ST, Harmon W, Packard A, Kuruc A. Pediatric Nuclear Medicine/PET. Third Edition; 2007. p. 239-86.
4. Piepsz A, Colarinha P, Gordon I, Hahn K, Olivier P, Roca I, et al. Guidelines for 99mTc-DMSA scintigraphy in children. Eur J Nucl Med. 2001; 28(3): 37-41.

5. Jakobsson B, Berg U, Svensson L. Renal scarring after acute pyelonephritis. Arch Dis Child. 1994; 70(2): 111–5.
6. Patel K, Charron A, Hoberman A, Brown ML, Rogers KD. Intra- and interobserver variability in interpretation of DMSA scan using a set of standardized criteria. Pediatr Radiol. 1993; 23(7): 506–9.
7. Gacinovic S, Buscombe J, Costa DC, Hılson A, Bomanji J, Ell PJ. Interobserver agreement in the reporting of 99mTc-DMSA renal studies. Nucl Med Commun. 1996; 17(7): 596–602.
8. Jaksić E, Beatović S, Žagar I, Punković I, Stefanović A, Ajdinović B, et al. Interobserver variability in the interpretation of Tc 99m DMSA renal scintigraphy: multicentric study. Nucl Med Rev. 1999;2(1):28-33.
9. Tondeur MC, De Palma D, Roca I, Piepsz A, Ham HH. Interobserver reproducibility in reporting on renal cortical scintigraphy in children: a large collaborative study. Nucl Med Commun. 2009; 30(4): 258-62.
10. Patel K, Charron A, Hoberman A, Brown ML, Rogers KD. Intra- and interobserver variability in interpretation of DMSA scan using a set of standardized criteria. Pediatr Radiol. 1993; 23(7): 506–9.
11. Gacinovic S, Buscombe J, Costa DC, Hilson A. Inter-observer agreement in the reporting of Tc-99m DMSA renal studies. Nucl Med Commun. 1996; 17(7): 596–602.
12. Caglar M, Kiratli PO, Karabulut E. Inter- and intraobserver variability of (99m) Tc-DMSA renal scintigraphy: impact of oblique views. J Nucl Med Technol. 2007; 35(2): 96-9.
13. Sampedro F, Domenech A, Escalera S, Carrio I. Computing quantitative indicators of structural renal damage in pediatric DMSA scans. Rey Esp Med Nucl Imagen Mol. 2017; 36(2): 72-7.

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